AIR FORCE OFFICE of SCIENTIFIC RESEARCH [AFOSR]
Manager of the Basic Research Investment for the Air Force

Research

HIGHLIGHTS

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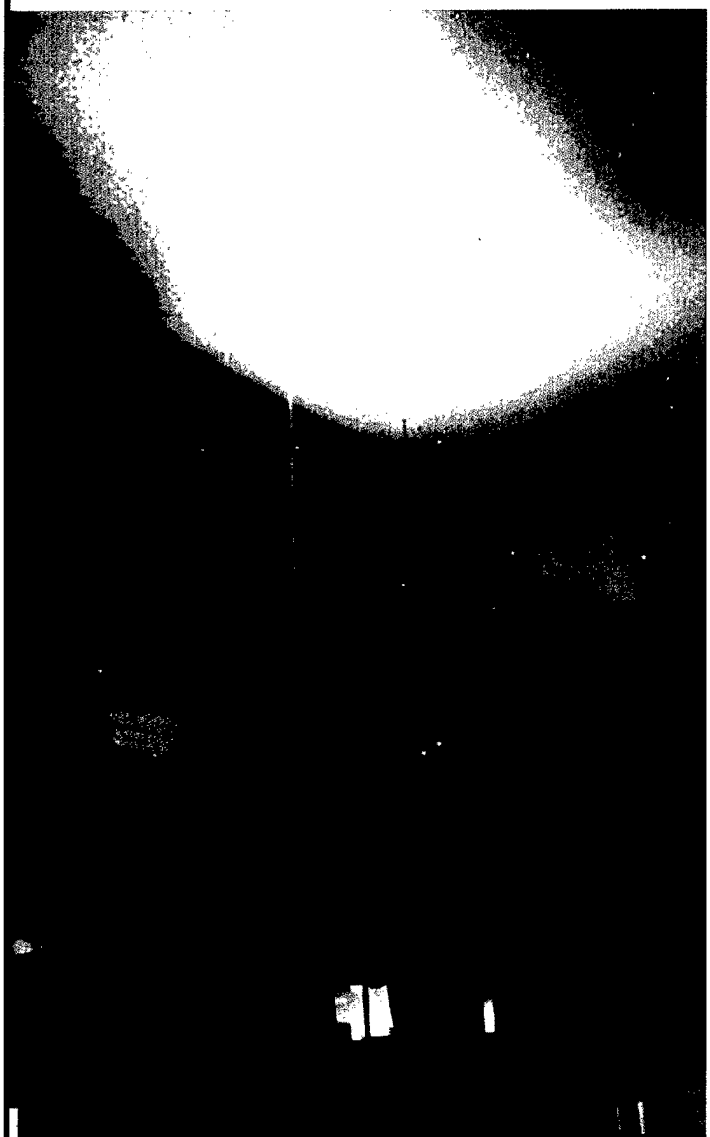
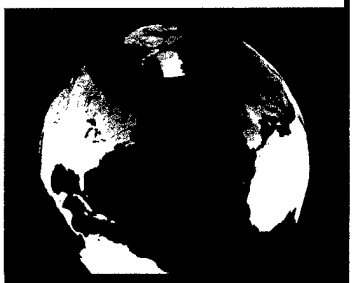
Laser Instrument Probes the Lower Boundary of the Ionosphere



The new AFOSR-sponsored Weber Sodium Lidar (yellow beam) and the ALOMAR Differential Absorption Lidar (green beam) probe the upper atmosphere in the auroral zone above the ALOMAR optical observatory.



Auroral oval phenomena: subject of lidar study

Visible laser light, like radio waves, can be reflected from suitable targets to reveal the motion and range of targets. Using radio waves, this technology is familiar to all of us as "radar" (for radio detection and ranging). Using lasers, the technology is called "lidar" (for light detection and ranging). However, due to the difference in wavelength between radio waves and laser light, lidars can detect much smaller targets than radars. Scientists have used this principle to create lidars for surveying the atoms and molecules of the upper atmosphere. Not only can such lidars detect atoms and their motions, but they can also determine particle temperature. AFOSR recently funded a lidar to probe the persistent layer of neutral sodium atoms found between 80 and 110 kilometers altitude, believed to be a by-product of incoming meteors vaporizing at the base of the Earth's ionosphere. This advanced lidar research project benefits the Air Force by:

1) enhancing USAF ability to forecast the structure and variability of the lower ionosphere and how it modulates satellite drag, which reduces DoD space systems' lifetimes and complicates satellite tracking;

2) improving USAF understanding of how ionospheric effects that characterize space weather (such as ionospheric scintillation, the degradation of radio-wave propagation analogous to the "twinkling of starlight") are coupled to phenomena in the lower atmosphere; and

3) providing a test-bed for developing the latest techniques in remote sensing of atmospheric constituents with lasers, providing a method to assess target chemical properties at a distance.

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Laser Instrument Probes the Lower Boundary of the Ionosphere

story continued from page 1...

The new Air Force lidar, constructed by Dr. Joe Chiao-Yao She and his research group in the Physics Department at Colorado State University (CSU), was completed in July 2000. It achieved "first light" on 13 August 2000, when it detected the sodium layer in daylight through clouds. The instrument is installed at the Arctic Lidar Observatory for Middle Atmosphere Research (ALOMAR) at Andoya, Norway, located at 69 degrees north latitude, in order to observe ionospheric phenomena in the auroral zone. This new instrument is named the "Weber" lidar, in honor of the late Dr. Edward Weber, an ionospheric physicist at the Air Force Research Laboratory, and the late Louis R. Weber, former Head of the CSU Physics Department. The CSU Weber lidar, supported with funding from the U.S. Defense University Research Instrumentation Program (DURIP), represents the state-of-the-art in innovative sodium resonance laser technology.

Many scientists contributed to the development of this unique instrument. CSU members include Dr. Hans Moosmuller, Mr. Joe Vance, Dr. Zhilin Hu, Mr. Vince Vasoli, Mr. Jim Sherman, Dr. Biff Williams, and Dr. Dave Krueger. Additional financial and technical support to configure the ALOMAR telescopes to accept the CSU Weber lidar was provided by Dr. Ulf von Zahn of the Institute of Atmospheric Physics (IAP) in Kuehlungsborn, Germany and his colleagues Drs. F. J. Luebken, now at IAP, and K. Fricke and G. Baumgarten of Bonn University, Germany. Support to accommodate the Weber lidar at the ALOMAR observatory was provided by the Andoya Rocket Range in Norway, which operates ALOMAR in collaboration with the [illegible] Research Establishment.

Mated with ALOMAR's large twin, steerable mirrors (each 1.8 meter in diameter), the CSU Weber lidar becomes the only resonance lidar on Earth capable of nearly-continuous (weather permitting) measurements of the base of the ionosphere in the auroral zone. All other lidars are restricted to observation at night, leaving large gaps in data coverage. The Weber lidar will be used for such 24-hour measurements by Dr. Joe She of CSU, Dr. Dave Fritts of Colorado Research Associates/ Northwest Research Associates, and their colleagues under continuing funding from AFOSR to maximize the benefits to the Air Force of the DURIP investment.

Dr. David Fritts (backgound) and Dr. Joe Chiao-Yao She (foreground) in the lidar laboratory

The CSU Weber lidar measurement accuracy and ALOMAR telescope pointing capability will permit studies of:

1) the large-scale circulation and structure of the base of the ionosphere in the auroral zone;
2) the role of various atmospheric waves (planetary, tidal, and gravity waves) that propagate from upward from lower altitudes and contribute to ionospheric variability; and
3) the driving of upper atmosphere fluctuations by the fluxes of momentum and heat accompanying these waves.

Studying these phenomena will enable the Air Force to better specify and forecast ionospheric scintillation and variability. This in turn will lead to more reliable and accurate space-based surveillance, communications, and navigation for the DoD.

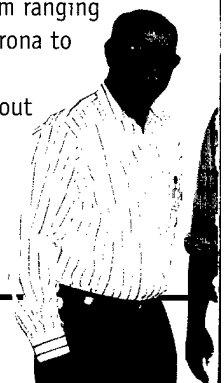
Major Paul Bellaire, AFOSR/NM (703) 696-8411;
Dr. Joe C. Y. She, Colorado State University;
Dr. David Fritts, Colorado Research Associates

COMMUNITY COORDINATE

On 16 August 2000, Brigadier General David Johnson, Air Force Director of Weather at the Pentagon (HQ USAF/XOW), and Colonel Steven Reznick, AFOSR Deputy Director/ Commander (AFOSR/CD), attended the ribbon-cutting ceremony for the Community Coordinated Modeling Center (CCMC) at NASA Goddard Space Flight Center, Maryland. Senior Executive Service personnel from NASA and the NSF have commended the AFOSR leadership for playing a visionary role in the founding of this new Center. Through the CCMC, AFOSR will be the link bringing space weather basic research results to the USAF operational community.

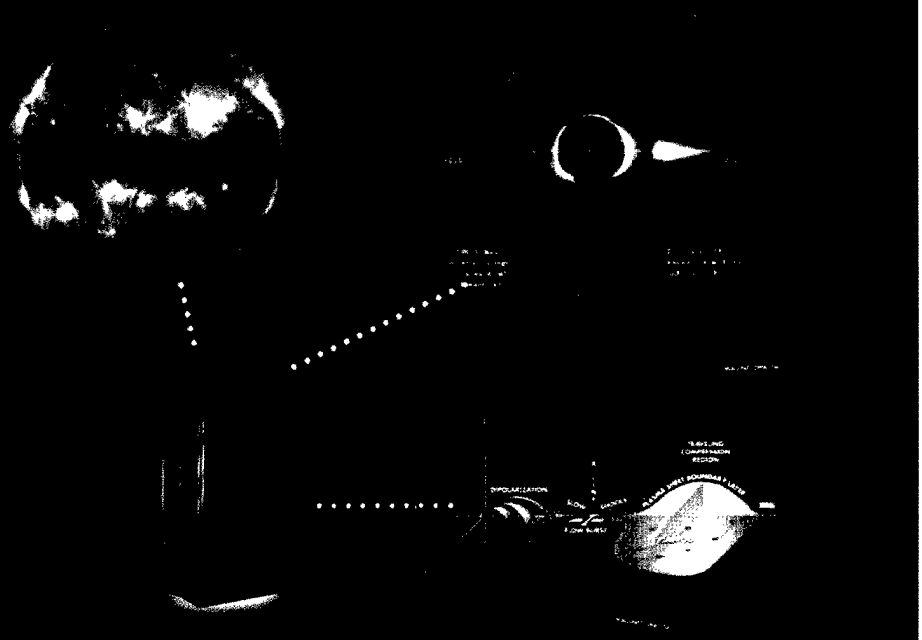
Along with the Air Force Weather Agency (AFWA), the National Oceanic and Atmospheric Administration (NOAA), the Air Force Materiel Command (AFMC), and the Air Force Research Laboratory (AFRL), AFOSR plays a key enabling role in the CCMC and collaborates with the National Science Foundation (NSF) and NASA in providing basic research support. Members of these organizations serve on the CCMC Steering Committee. The CCMC web page at http://ccmc.gsfc.nasa.gov contains links to all participating agencies.

This innovative interagency partnership will create, with research community involvement, comprehensive space weather models for the region of the solar system ranging from the Sun's corona to the Earth's upper atmosphere. Without such partnering, efforts of this magnitude could not succeed,



View of the entire atmospheric layer from the space shuttle (courtesy of NASA)

AFOSR Enables A Cutting-edge Space Weather Forecasting Center



The logo of the CCMC (from left to right, top to bottom) includes images of the Sun seen in X-rays and the Sun with an overlay pattern showing that solar wind speeds are strongest near the solar poles and weak near the solar equator; an IBM SP2 supercomputer, and a graphical depiction of current flows and plasma configuration in the Earth's magnetosphere.

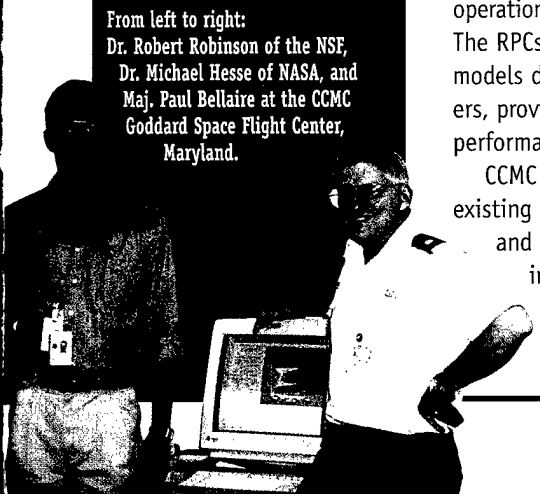
and AFOSR's contribution has been pivotal. The CCMC is a top priority project of AFWA, NASA's new "Living With A Star" solar-terrestrial physics program, and the National Space Weather Program (NSWP). The NSWP is a multi-agency effort to improve the nation's space weather forecasting capabilities over the next decade. AFOSR has been a key participant in the NSWP since the program's inception in 1995. The CCMC partnership will enable, support, and perform the research and development needed for next-generation space science and space weather models, thereby furthering NSWP objectives.

The CCMC bridges a long-standing gap between the space science community and operational space weather forecasting units in the DoD and NOAA. These operational units are responsible for providing space weather services to a large and growing national customer base. Both the DoD and NOAA are creating Rapid Prototyping Centers (RPCs) which will implement space weather models at their respective operational centers in Nebraska and Colorado. The goal of the CCMC is to facilitate the development, validation, and testing of new space weather models, which can then be adapted for operational use at the RPCs. The RPCs will also accept models directly from developers, provided a standard set of performance criteria are met.

CCMC staff will integrate existing research-grade models and perform basic research in space plasma physics as required to further space weather goals. The CCMC will also utilize comprehensive data-bases available at the Goddard Space Flight Center (GSFC) to develop and exercise the models in preparation for transferring them to the RPCs. The CCMC will provide advanced computer assets for the testing and validation of the most complex and sophisticated space physics models now in existence.

Conceptually, the CCMC was initiated in 1998 by Mr. Kevin Scro of AFMC's Space and Missile Systems Center as a part of DoD efforts to provide more effective transition of research models into operations. Subsequent multi-agency efforts led to a notional design and management plan for the CCMC, which are still evolving. The participating agencies have enabled the CCMC and its activities by providing computational assets, physical infrastructure, scientific and technical support, and post-doctoral research support.

The CCMC reached its initial operational capability in June 2000. Currently, the CCMC uses 32 IBM SP2 processors at AFWA in Omaha, Nebraska. Front-end computers and workstations at the CCMC share a high-speed data link between Nebraska and Maryland via the Defense Research Engineering Network (DREN) to ensure immediate and seamless computing operations. Visiting students and scientists will be invited to GSFC as required during model development and testing. The CCMC Steering Committee plans to select post-docs every two years as part of the NSWP proposal competition.



From left to right: Dr. Robert Robinson of the NSF, Dr. Michael Hesse of NASA, and Maj. Paul Bellaire at the CCMC Goddard Space Flight Center, Maryland.

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Dr. Robert Robinson, NSF Upper Atmospheric Research Section (703) 292-8529; and

Dr. Michael Hesse, NASA Goddard Space Flight Center, (301) 286-8224

ESEP Participants

The DoD Engineer and Scientist Exchange Program, or ESEP, supports science and technology through international cooperation in military research, development, and acquisition through the exchange of defense scientists and engineers. ESEP provides on-site assignments for U.S. military and civilian scientists and engineers in foreign government organizations and reciprocal assignments of foreign scientists and engineers in U.S. government organizations. ESEP supports current USAF science and technology requirements by seeking specific foreign technologies. It provides insight into the technology and project management techniques of foreign laboratories and centers and opens areas of possible technical cooperation.

Dr. Jerry Franck,
Progam Manager
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GERMANY

Capt. Richard Branam, from AFRL/PRRE, Edwards AFB, CA, is a Rocket Propulsion Engineer who managed a Stage Demonstrator Program for a thrust LH_2/LO_2 rocket engine. His assignment to the Rocket Propulsion Division of the Deutsches Zentrum für Luft-und Raumfahrt (DLR) Lampoldshausen, Germany, will continue his rocket research by investigating application of optical techniques for flow and combustion diagnostics. Capt. Branam received a M.A. degree in Aeronautical Engineering from the Air Force Institute of Technology.

FRANCE

Dr. Joseph Chris Sturgis, an aerospace engineer at AFRL/PRRE, Edwards AFB, CA, has developed, managed, and engineered an experimental in-house project to examine thermal and hydrodynamic characteristics of high aspect ratio coolant channels. His assignment is to the Office National d'Etudes et de Recherches Aérospatiales (ONERA), Palaiseau (Paris) France, to study the effect of rotation on the level of convective heat transfer within the internal cavities of air cooled rotor blades. Dr. Sturgis obtained his Ph.D. in Mechanical Engineering from Purdue University.

ISRAEL

Capt. Matthew Yocum, an instructor in the engineering mechanics department of the US Air Force Academy, conducted research on damage accumulation of ceramic matrix composites and also served as a Squadron Professional Ethics Advisor to a cadet squadron. Capt. Yocum authored a textbook used for the Academy's core engineering mechanics course now used by nearly 500 students each semester. Under the Engineer and Scientist Exchange Program, he is assigned to the Aircraft Structures Laboratory, Faculty of Aerospace Engineering, Technion, Haifa, Israel where he will conduct research in the area of composite materials and smart structures. Capt. Yocum obtained his M.A. in Mechanical Engineering from the Air Force Institute of Technology.

Research Highlights

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Research Highlights is published every two months by the Air Force Office of Scientific Research. This newsletter provides brief descriptions of AFOSR basic research activities including topics such as research accomplishments, examples of technology transitions and technology transfer, notable peer recognition awards and honors, and other research program achievements. The purpose is to provide Air Force, DoD, government, industry and university communities with brief accounts to illustrate AFOSR support of the Air Force mission. *Research Highlights* is available on-line at:

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